

Figure 1. The effect of the number of iterations (n) on the accuracy of the proposed algorithm. The error is defined as the difference between the exact solution and the numerical solution. The error decreases as the number of iterations increases.

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like alternate patterns or different wire sizes are to be performed on the same leadframe. If the wire-bonder has multiple bond-heads on the same system that are substantially adjacent to each other, the different bonding processes can be carried out consecutively with less transportation time required to transfer the leadframe from one bond-head to another.

Summary of the Invention

Thus, the invention seeks to provide an improved wire-bonding system comprising multiple bond-heads to avoid some of the disadvantages of the prior art consisting of single bond-head systems.

Accordingly, the invention provides a wire-bonding apparatus for forming electrical connections between a semiconductor chip and a leadframe, comprising a plurality of bond-heads associated with a plurality of work holders on said wire bonding apparatus for holding a plurality of leadframes, wherein each bond-head of the apparatus is capable of independent bonding operation simultaneously with the other bond-heads, without synchronization of movement with the other bond-heads.

It will be convenient to hereinafter describe the invention in greater detail by reference to the accompanying drawings which illustrate one embodiment of the invention. The particularity of the drawings and the related description is not to be understood as superseding the generality of the broad identification of the invention as defined by the claims.

Brief Description of the Drawings

Figure 1 is a front elevation view of a single-head wire-bonder of the prior art.

Figure 2 is a front elevation view of a twin-head wire bonder according to a preferred embodiment of the invention.

Figure 3 is a front elevation view of two twin-head wire-bonders configured adjacent to each other as part of an in-line system for the assembly of semiconductor packages according to another embodiment of the invention.

- 5 Figure 4 is a front view of a cardcage usable with the preferred embodiments of the invention

- Figure 5 is a schematic plan view of a twin-head wire-bonder that illustrates one work-flow configuration for the wire-bonding of leadframes according to
10 the second preferred embodiment of the wire-bonding system.

- Figure 6 is a schematic plan view of a twin-head wire-bonder that illustrates another work-flow configuration for the wire-bonding of leadframes as an alternative to Figure 5.

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Detailed description of the preferred embodiment of the invention

- Figure 1 is a front elevation view of a single head wire-bonder 100 of the prior art. The single-head wire-bonder 100 has a work holder 102 located
20 substantially centrally on the single-head wire-bonder 100 for holding and indexing leadframes during the wire-bonding process. Wires are bonded to the leadframes using bond-head 104, commonly an ultrasonic transducer, in a process referred to as wedge bonding. The single-head wire-bonder 100 that is illustrated has a stand-alone configuration, and therefore, magazines 106,
25 108 can be used to store unprocessed as well as processed leadframes. Unprocessed leadframes may be stored in the left magazine 106 supported by a left elevator 110, whereas processed leadframes can be stored in the right magazine 108 supported by a right elevator 112.

- 30 There is optionally a set of computer monitors 114 to monitor the progress of the wire-bonding as well as to assist in setting the parameters for the wire-bonds. The foregoing components sit on a lower chassis with a cardcage 116.

Figure 2 is a front elevation view of a twin-head wire-bonder 10 according to a preferred embodiment of the invention. The wire-bonder 10 has two work holders 12, 14 positioned adjacent to each other. The work holders 12, 14 can each hold and index a leadframe such that two leadframes may be processed simultaneously. The work holders can be indexed in the x-axis. There are two bond-heads 16, 18, each of which is positioned above a work holder 12, 14, for wiring the semiconductor chips located on each leadframe. The bond-heads 16, 18 are movable in the x- and y-axes. Although for ease of understanding the invention, only two bond heads are illustrated in the preferred embodiment, it would be appreciated that the apparatus can be manufactured with more than two bond-heads associated with more than two work holders.

Each bond-head 16, 18 is controlled by a separate controller board so that it is capable of independent bonding operation, although the bond-heads are operated simultaneously. Thus the bond-heads 16, 18 are capable of simultaneous bonding of different types of wires. For example, one bond-head could conduct bonding with gold wires and another bond-head could simultaneously conduct bonding with copper wires, or wires of different diameters could be used by different bond-heads at the same time. Further, each bond-head could conduct bonding with a different pattern.

Due to the vibrations that would be generated by the simultaneously ongoing bonding processes, it is desirable to leave a gap between the work holders 12, 14 so that vibration caused on one work holder will not affect the accuracy of bonding on the other. Each of the work holders 12, 14 rests on a separate base platform, wherein each base platform is separated from another by a gap. Each base platform is in turn separated from direct contact with a common lower chassis on which it rests by a vibration-insulating material to minimize transmission of vibration from one base platform to the other.

Figure 2 illustrates the wire-bonder 10 with a stand-alone configuration, such that storage means, such as magazines 20, 22 can be used to store unprocessed leadframes in one magazine 20 as well as processed

leadframes in the other magazine 22. The left magazine 20 is supported by a left elevator 24 and the right magazine 22 is supported by a right elevator 26. Each magazine 20, 22 has a plurality of slots (not shown) aligned with the orientation of the leadframes when they are being transported, each of the slots being designed to store a leadframe. The left and right elevators 24, 26 raise and lower the left and right magazines 20, 22. When a leadframe stored in the magazine 20 is elevated to register with the work holders 12, 14, a kicker mechanism pushes the leadframe out of the left magazine 20 and onto the left work holder 12. The leadframe may also be moved to the right work holder 14 for wire-bonding to be performed there. After wire-bonding has been performed, there is another kicker mechanism adjacent to the right work holder 14 to push the processed leadframe into an empty slot in the right magazine 22 for storage. Each slot of the magazine 22 is elevated in turn by the right elevator 26 to register with the right work holder 14 consecutively until the magazine 22 is filled.

Optionally, the wire-bonder 10 may include computer monitors 28 to monitor the progress of the wire-bonding as well as assisting in setting the parameters for the wire-bonds. The foregoing components sit on a lower chassis with a cardcage 30. It would be appreciated that the foot-print of the twin-head wire-bonder 10 (as determined by the base area of the lower chassis) is substantially similar to that of the single-head wire-bonder 100 although the capacity of the wire bonder 10 has been increased, thus reducing the footprint that would previously be required for two single-head wire-bonders 100.

Figure 3 is a front elevation view of two twin-head wire-bonders 10, 11 configured adjacent to each other as part of an in-line system for the assembly of semiconductor packages according to another preferred embodiment of the invention. The difference between an in-line system and a stand-alone system is that in the in-line system, leadframes are transported directly from one processing machine (such as a die-bonder, wire-bonder, moulding machine and inspection machine) to another. Therefore, magazines are not necessary to store leadframes for transportation between one machine or set of machines to another.

The second twin-head wire-bonder 11 has similar work holders 13, 15 and bond-heads 17, 19 positioned above the work holders 13, 15. There may also optionally be computer monitors 29 to monitor the progress of the wire-bonding and to assist in setting parameters for the process. The components
5 are similarly supported on a lower chassis and cardcage 31

However, in this in-line configuration, there is no need for magazines 20, 22 or the left and right elevators 24, 26 which are preferable in the stand-alone
10 configuration. Instead a line transporter 38 (see Figure 5) including a series of rollers 32, 33 is used to transport leadframes from one machine to another. Other processing machines in the in-line (not shown) would preferably have similar line transporters 38 to receive or transfer leadframes to be processed. As it is preferable to have more than one transport path for the leadframes, as
15 will be explained in more detail below, transport arms 34, 35, 36, 37 may be used to carry leadframes from one transport path to the other.

Figure 4 is a front view of a cardcage 30 usable with the preferred embodiment of the invention. There is a main computer 60 with a
20 microprocessor for controlling the functions of the various components that are stored in the cardcage. The components will be described in turn.

The cardcage 30 includes a right Z-movement driver 62, a right XYZ board with an embedded computer 64, and right input/output Bond Quality
25 Monitoring board 66 to control bonding on the right side. Correspondingly, there is a left input/output Bond Quality Monitoring board 68, left XYZ board with an embedded computer 70 and left input Z-movement driver 72 to control bonding on the left side. The advantage of having embedded computers (not shown) on the XYZ boards 64, 70 is that the processes can run faster and
30 more efficiently, and take up less space as compared to having a separate dedicated personal computer to control the boards.

In addition, the cardcage 30 includes a work holder board 74 with embedded computer, an AC and stepper board 76, two Low Voltage quad stepper

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After wire-bonding is completed, the leadframes 40 are moved in the reverse directions C2 and D1, and back to the line transporter 38.

5 It should be appreciated that the described embodiment of the invention achieves an independent multiple-head bonding system design, and interference between individual bond-heads is minimized.

10 The invention described herein is susceptible to variations, modifications and/or additions other than those specifically described and it is to be understood that the invention includes all such variations, modifications and/or additions which fall within the spirit and scope of the above description.